

## Advanced Clothing Studies

All human space missions require significant logistical mass and volume that add an unprecedented burden on long-duration missions beyond low-Earth orbit. For these missions with limited cleaning resources, a new wardrobe must be developed to reduce this logistical burden by reducing clothing mass and extending clothing wear. The present studies have been undertaken, for the first time, to measure length of wear and to assess the acceptance of such extended wear.

Garments in these studies are commercially available exercise T-shirts and shorts, routine-wear T-shirts, and long-sleeved pullover shirts. Fabric composition (cotton, polyester, light-weight, superfine Merino wool, modacrylic, cotton/rayon, polyester/Cocona, modacrylic/Xstatic, modacrylic/rayon, modacrylic/lyocell/aramid), construction (open knit, tight knit, open weave, tight weave), and finishing treatment (none, quaternary ammonium salt) are the independent variables.

Eleven studies are reported here: five studies of exercise T-shirts, three of exercise shorts, two of routine wear T-shirts, and one of shirts used as sleep-wear. All studies are conducted in a climate-controlled environment, similar to a space vehicle's. For exercise clothing, study participants wear the garments during aerobic exercise. For routine wear clothing, study participants wear the T-shirts daily in an office or laboratory. Daily questionnaires collected data on ordinal preferences of nine sensory elements and on reason for retiring a used garment.

Study 1 compares knitted cotton, polyester, and Merino exercise T-shirts (61 participants), study 2, knitted polyester, modacrylic, and polyester/Cocona exercise T-shirts (40 participants), study 3, cotton and polyester exercise shorts, knitted and woven (70 participants), all three using factorial experimental designs with and without a finishing treatment, conducted at the Johnson Space Center, sharing study participants.

Study 4 compares knitted polyester and ZQ Merino exercise T-shirts, study 5, knitted ZQ Merino and modacrylic routine-wear T-shirts, with study 6 using only knitted polyester exercise shorts. No finishing treatment is used. Studies 4 and 5 use cross-over experimental designs, and all three studies were conducted aboard the ISS with six crew. Studies 4 and 6 were repeated on the ground with the same participants to learn if perception was affected microgravity.

Study 7 is a longer-term, single-blind panel study of knitted routine-wear undershirts with at least 12 participants to assess tolerance to Merino by comparing it with a cotton/rayon blends, using a cross-over design, eliminating carry-over effects with wash-out periods between shirts.

Studies 8 and 9 were conducted over 16 weeks as part of the simulated long-duration Mars surface mission operated by the Hawai'i Space Exploration Analog and Simulation (HI-SEAS) project in Spring 2013 with six participants. Study 8 uses a cross-over design to compare knitted polyester/Cocona, modacrylic, and modacrylic/Xstatic exercise T-shirts, some with a finishing treatment. Study 9 compares long-sleeved, flame-retardant pullover shirts, used as sleep-wear, in modacrylic/rayon and modacrylic/lyocell/aramid with and without a finishing treatment.

Studies 10 and 11 were conducted over 16 weeks by HI-SEAS in Summer 2014 with 5 participants. Study 10 compares knitted polyester, wool, and modacrylic exercise T-shirts, study 11, knitted cotton exercise shorts, with and without finishing treatment, versus knitted polyester exercise shorts.